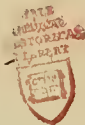


George Blumer

VACCINATION AND ITS RELATION TO ANIMAL EXPERIMENTATION

"The humanity which would prevent human suffering is a deeper and truer humanity than the humanity which would save pain or death to animals."—*Charles W. Eliot.*



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VACCINATION AND ITS RELATION TO ANIMAL EXPERIMENTATION

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I. VACCINATION

Thomas Jefferson, writing in 1806 to Edward Jenner, the discoverer of vaccination, said: "Future nations will know by history only that the loathsome smallpox has existed and by you has been extirpated." The prediction of this sagacious statesman would ere this have been fulfilled if vaccination and revaccination had been universally practiced. Despite one hundred years of incontrovertible testimony of the efficacy of adequate vaccination as a safeguard against smallpox, and despite an almost complete unanimity of opinion among scientific medical men of the century, there still remain some laymen and a few physicians who dissent from the generally accepted view.

In writing, therefore, on the increase of our knowledge of vaccination and smallpox in its relation to animal experimentation and research, it will be desirable to preface the same by a discussion of the efficacy of vaccination as a prophylactic measure against smallpox.

In order to appreciate the importance of Jenner's discovery of vaccination, it is necessary to comprehend how extensive and fatal was smallpox in the prevaccination period.

The date of the origin of smallpox, as is true with many of the pestilential diseases, is involved in some obscurity. While there are references in literature to diseases suggestively corresponding to smallpox dating back many centuries, we have no trustworthy record of the extent of its prevalence before the fifteenth century. The probabilities are that it made its first appearance in the Orient and was thence introduced into Western Europe. Epidemics of this disease became progressively more

common during the seventeenth century and reached their maximum of frequency and extent in the eighteenth century. For official data concerning the disease in the seventeenth and eighteenth centuries we are largely indebted to the London "Bills of Mortality," which gave a weekly account of burials and christenings, and from 1629 to 1845 the specific causes of death, including smallpox.

It has been estimated that the population of London in 1685 was 530,000; in 1750 it was approximately 653,900; in 1801 it was determined by census to be 746,233.

The mortality from smallpox in London for an average of ten years, from 1681 to 1690, was over 3 per thousand of population (3,000 per 1,000,000); in the seventeenth and eighteenth centuries it frequently rose to 4.5 or more per thousand.

In the 54 years from 1647 to 1700, there was an average mortality from smallpox in London of 1,079 per year. The average yearly deaths by smallpox in the eighteenth century were 1,958. As it has been computed that about one in five died, it would appear that there were on an average over 5,000 cases of smallpox annually in the English capital in the seventeenth century, and almost 10,000 cases a year in the eighteenth century.

As will be readily comprehended, smallpox was a great scourge before the days of vaccination; but a small percentage of people escaped its ravages. It is asserted by contemporaneous writers that in the eighteenth century from 85 to 95 per cent. of the inhabitants of European countries suffered at one time or another from the smallpox.

Indeed, smallpox was as prevalent in the eighteenth century as measles is at the present time. Haygarth gives an account of an epidemic of smallpox in Chester, England, in 1744, at which time, out of a population of 14,713, 1,202 persons took the disease and 202 died. At the termination of the epidemic there were but 1,060 persons, or 7 per cent. of the population who had never had smallpox.

In 1722 smallpox devastated the small English town of Ware, whose population numbered 2,515 souls; of this number, there were only 914 persons susceptible to smallpox, inasmuch as 1,601 had already passed through an attack of the disease. During the epidemic referred

to, 612 persons were attacked, leaving but 302 individuals in the entire town who had never had smallpox. Eighty-five per cent. of the population, therefore, were smallpox survivors.

With these official figures in mind, we may be better able to appreciate the general estimate of the extent of smallpox given by writers of the day. In 1802 Admiral Berkeley, in a speech before the House of Commons, said:

It is proved that in this United Kingdom alone 45,000 persons die annually of the smallpox; but throughout the world what is it? Not a second is struck by the hand of Time but a victim is sacrificed upon the altar of that most horrible of all disorders, the smallpox.

King Frederick William III. of Prussia, in a dispatch, dated Oct. 31, 1803, stated that 40,000 people succumbed annually to smallpox in his kingdom.

The French physician, De la Condamine,¹ stated that "every tenth death was due to smallpox, and that one-fourth of mankind was either killed by it or crippled or disfigured for life."

Junker, professor of medicine in Halle in 1796-98, gathered statistics indicating that 65,220 persons died of smallpox in the German-speaking countries in 1796.²

Sarcone³ estimated the number of persons in Italy who suffered from smallpox as nine-tenths of the population. He states that in Rome in 1754 smallpox destroyed more than 6,000 lives.

Smallpox was introduced into the western hemisphere by the Spaniards about fifteen years after the discovery of America; in Mexico within a short period 3,500,000 persons are said to have died of the disease.⁴

It is alleged that in Mexico smallpox has exterminated whole tribes of Indians, sparing no one to tell the story of the annihilation.

Robertson refers to smallpox among the South American Indians as follows:⁵

In consequence of this [various calamities], together with the introduction of the smallpox, a malady unknown in Amer-

1. De la Condamine: *Mémoire sur l'inoculation de la petite vérole*, 1754.

2. Kübler: *Geschichte der Pocken und der Impfung*, 1901, p. 99.

3. Sarcone: *Childpox*, etc., translated from the Italian into German by Lentin, Goettingen, 1782.

4. Chapman: *Eruptive Fevers*, etc., 1844, quoting Robertson's *History of the Discovery of America*.

5. Robertson, William: *History of the Discovery and Settlement of America*, 1829, p. 348.

ica, and extremely fatal to the natives, the number of the people both in New Spain and Peru was so much reduced that in a few years the accounts of their ancient population appeared almost incredible.

Catlin⁶ states that, of 12,000,000 American Indians, 6,000,000 fell victims to smallpox.

Washington Irving's "Astoria" makes mention of terrible epidemics of smallpox among the Indians in which "almost entire tribes were destroyed."

Lloyd, who translated Prince Maximilian's "Travels in the Interior of North America," states in the preface, in reference to a smallpox epidemic among the Indians in 1837:

The Big-Bellied Indians and the Ricarces, lately amounting to 4,000 souls, were reduced to less than the half. The Assiniboin, 9,000 in number . . . are, in the literal sense of the expression, nearly exterminated.⁷

According to records published by the government of Denmark, a devastating epidemic of smallpox appeared in Iceland in 1707 which destroyed 18,000 out of the 50,000 inhabitants; 36 per cent. of the total population perished. It is stated on good authority that in the Danish colony of Greenland, in 1734, 6,000 to 7,000 persons perished from smallpox, representing nearly two-thirds of the population. The disease was introduced by a Danish ship.

The natives of New England likewise suffered great losses by smallpox. Robertson writes:

At the same time, about 1631, the smallpox, a distemper fatal to the people of the New World, swept such multitudes of the natives that some whole tribes disappeared.

In 1752 Boston had a severe epidemic of this dread disease. The population of Boston at that time was 15,684; of this number, 5,998 had previously had smallpox. During the epidemic 5,545 persons contracted the disease in the usual manner, and 2,124 took it by inoculation. Eighteen hundred and forty-three people escaped from the town to avoid the danger of infection.⁸ There were, therefore, left in the city but 174 people

6. Catlin: Letters and Notes on the Manners, Customs and Conditions of the North American Indians, London, 1841.

7. Extracts from a paper prepared by Sir. John Simon in 1857, and presented by him before the Royal Commission on Vaccination in 1889. Appendix No. 1, p. 63.

8. Gentlemen's Magazine, 1753.

who had never had smallpox. The population at the end of the epidemic practically consisted of persons who had survived an attack of this fear-inspiring malady.

CHANGE IN THE AGE INCIDENCE

Smallpox was essentially a disease of children in former times; to such an extent was this true that the disease was called *Kindspocken* (childpox, or *Kindsblattern*). Owing to the pronounced contagiousness of the disease and the almost universal susceptibility to it, smallpox was largely contracted during child life, as measles is at the present time. But comparatively few adults contract measles at the present day because they are protected by a previous attack in infancy or childhood. The same conditions obtained with relation to smallpox in the days before vaccination. The adult population represented mostly the survivors from smallpox in childhood. It was estimated that only about 5 per cent. of persons were naturally insusceptible to the disease. Vaccination has totally changed the age period of smallpox. It is now excessively rare for a successfully vaccinated child under five years of age to die of the smallpox; it is even uncommon for a successfully vaccinated child under ten years of age to die of the disease, as was adequately proved in the testimony presented before the British Royal Commission on Vaccination.

The almost exclusive mortality of smallpox among infants and children in the days before vaccination is exemplified in the smallpox statistics of Kilmarnock from 1728 to 1764, a period of thirty-one years. During this time the total deaths were 3,860, and the deaths from smallpox 622. There were nine epidemics of smallpox recurring at intervals of about four years. Of the 622 smallpox deaths, 586 were in children under six years of age, 27 occurred in persons over the age of six, and the age of nine persons were not known.

In Chester, in the epidemic of 1774, all of the smallpox deaths, numbering 202, occurred in children under ten years of age and one-quarter of them under one year.

In Kilmarnock, of 622 deaths from smallpox between 1728 and 1763, only seven were of those above ten years.

In 1733 Warrington sustained an epidemic of smallpox which resulted in 211 deaths (population 8,000). In 1893 another epidemic occurred which resulted in 62

deaths (population 54,084, of whom 53,645 were vaccinated). The ages of the patients attacked are given in Table 1.

TABLE 1.—AGE OF SMALLPOX PATIENTS IN WARRINGTON, 1773 AND 1893

Age.	1773	Not Vaccinated Vaccinated.	
		—1893—	
Under 1 year.	49	0	8
1 to 2 years.	84	0	1
2 to 3 years.	33	0	0
3 to 4 years.	18	0	1
4 to 5 years.	15	0	1
5 to 6 years.	4	0	0
6 to 7 years.	2	0	0
7 to 8 years.	2	0	0
8 to 9 years.	4	1	1
9 to 15 years.	0	1	1
15 to 20 years.	0	1	2
20 to 30 years.	0	10	4
30 to 60 years.	0	24	5
Over 60 years.	0	1	0
	211	38	24

* Under 1 month.

In 1773 all of the deaths were under ten years and nine-tenths were under five years of age.

In 1893 among the vaccinated not a death occurred under eight years of age; indeed, not one vaccinated child under eight years of age contracted smallpox.

BLINDNESS AFTER SMALLPOX

People hold smallpox in great dread with good reason. Not only does this disease destroy life, disfigure and maim, but in the past it has been one of the most common causes of blindness. The early records of the London Asylum for the Indigent Blind showed that two-thirds of the inmates had lost their sight through smallpox.⁹

According to Sir William Aitkin, 90 per cent. of the cases of blindness encountered in the bazaars of India are due to smallpox.

Surgeon-General Pinkerton, in the service of the government of India, testified before the Royal Commission on Vaccination that blindness after smallpox was so common in India that a new word, "Kanu," was added to the Scindi language, the word meaning blindness in one eye.

Dr. Thomas W. Grimshaw, Registrar General for Ireland, testified before the commission that "the number

9. Blane, Sir Gilbert Med.-Chir. Tr., x, 326.

of cases in which blindness is attributed to smallpox diminished from 725 in 1861 to 359 in 1881."

TABLE 2.—BLINDNESS FROM SMALLPOX IN IRELAND

Year.	—Blind in Ireland—		Total No. Deaths From Smallpox in Preceding 10 Years.	Cases in Which Blind- ness was ascribed to Smallpox.	
	No.	Ratio to Population.		No.	Ratio to Total Number of the Blind.
1851	7,587	1 in 861	38,275	725	1 in 9.5
1861	6,879	1 in 843	12,727	526	1 in 12
1871	6,347	1 in 852	2,852	359	1 in 17
1881	6,111	1 in 847	7,550		

In the Municipal Hospital of Philadelphia during a period of over 35 years, but two smallpox patients have left the institution totally blind. Many patients with severe smallpox lose both of their eyes, but fortunately these patients usually succumb to the disease. The loss of one eye is, however, by no means rare. In the epidemic of 1901-1904 (which was not particularly severe), during which over 3,500 cases of smallpox were treated, 17 patients suffered the loss of an eye, despite most careful treatment; most of these patients were unvaccinated.

DECLINE OF SMALLPOX AFTER THE INTRODUCTION OF VACCINATION

In most of the countries of western Europe there was noted about the beginning of the nineteenth century a sudden and pronounced decrease in the morbidity and mortality of smallpox. Inasmuch as this was coincident with the diffusion of the practice of vaccination, there is strong reason to regard Jenner's epoch-making discovery as the causative influence. The careful records of smallpox mortality which were kept in various countries, particularly in Sweden and England, make it possible to prove by documentary evidence that a marvelous decrease in the deaths from smallpox occurred within a short period after the introduction of vaccination. In the twenty-eight years before vaccination in Sweden there died each year from smallpox out of each 1,000,000 of population 2,050 persons; during the forty years following vaccination, out of each 1,000,000 of population the smallpox deaths annually averaged 158.

During the seven years preceding the introduction of vaccination in Prague, smallpox caused one-twelfth of the total number of deaths; during the twenty years following the introduction of vaccination, smallpox caused but one four-hundred-and-fifty-seventh of the total number of deaths.

TABLE 3.—ANNUAL SMALLPOX DEATHS IN SWEDEN BEFORE AND AFTER THE INTRODUCTION OF VACCINATION *

Before Vaccination		1805	1806
1749†	4,453	1,090	1,482
1750	6,180	1,807	2,129
1751	5,546	1,808	1,814
1752	10,302	1809	2,404
1753	8,000	1810‡	824
1754	6,862	1811	689
1755	4,705	1812	404
1756	7,858	1813	547
1757	10,241	1814	308
1758	7,104	1815	472
1759	3,910	1816	690
1760	3,568	Compulsory Vaccination in	
1761	5,731	Infancy	
1762	9,380	1817	242
1763	11,662	1818	305
1764	4,562	1819	161
1765	4,697	1820	143
1766	4,092	1821	37
1767	4,180	Total (20 years) ..	
1768	10,650	18,217	
1769	10,215	Compulsory Vaccination in	
1770	5,215	Infancy	
1771	4,362	1822	11
1772	5,435	1823	39
1773	12,130	1824	618
1774	2,065	1825	1,243
1775	1,275	1826	625
1776	1,503	1827	600
1777	1,943	1828	257
1778	6,607	1829	53
1779	15,102	1830	104
1780	3,374	1831	612
1781	1,485	1832	622
1782	2,482	1833	1,145
1783	3,915	1834	1,049
1784	12,456	1835	445
1785	5,077	1836	138
1786	671	1837	361
1787	1,771	1838	1,805
1788	5,462	1839	1,934
1789	6,764	1840	650
1790	5,893	1841	237
1791	3,101	1842	58
1792	1,939	1843	9
1793	2,103	1844	6
1794	3,964	1845	6
1795	6,740	1846	2
1796	4,503	1847	13
1797	1,733	1848	71
1798	1,357	1849	341
1799	3,756	1850	1,376
1800	12,032	1851	2,488
1801	6,957	1852	1,534
Total (53 years) ..		1853	279
After Vaccination		1854	204
1802	1,533	1855	41
1803	1,464		
1804	1,460		

* The population in 1751 was 1,785,727; in 1855, it was 3,639,332.

† From 1749 to 1773 inclusive, deaths from measles are included.

‡ First successful vaccination in Stockholm.

TABLE 4.—POPULATION, TOTAL DEATHS, AND DEATHS BY
SMALLPOX DURING SEVEN YEARS BEFORE THE
GENERAL INTRODUCTION OF VACCINA-
TION IN PRAGUE *

Year.	Population.	Deaths		Remarks.
		Total Number.	From Smallpox.	
1796	3,003,346	92,242	6,686	The proportion of the deaths generally to population.—1:32.
1797	2,991,346	86,855	1,988	
1798	3,045,926	84,743	3,105	
1799	3,041,608	99,079	17,587	Deaths from smallpox to population.— 1:396 $\frac{2}{3}$.
1800	3,047,740	110,730	17,077	
1801	3,036,481	105,576	3,169	Deaths from smallpox to the total num- ber of deaths.— 1:12 $\frac{1}{3}$.
1802	3,111,472	85,460	4,029	
Total	21,278,055	664,685	53,641	
Average	3,039,722 $\frac{1}{7}$	94,955	7,663	

* Figures of the Medical Faculty of the University of Prague.
Published in Papers on Vaccination issued by the London Board
of Health, 1857.

TABLE 5.—POPULATION, TOTAL DEATHS, AND DEATHS BY
SMALLPOX DURING TWENTY-FOUR YEARS SUBSE-
QUENT TO INTRODUCTION OF VACCINATION
IN PRAGUE *

Year.	Population.	Deaths	
		Total No.	From Smallpox.
1832.....	3,888,828	139,061	807
1833.....	.....	121,679	533
1834.....	3,945,875	122,171	285
1835.....	.....	122,952	337
1836.....	.....	124,015	291
1837.....	4,027,581	141,982	104
1838.....	.....	108,419	62
1839.....	.....	121,400	128
1840.....	4,145,715	118,471	699
1841.....	.....	116,575	697
1842.....	.....	124,019	339
1843.....	4,285,730	142,876	332
1844.....	.....	113,184	150
1845.....	.....	178,826	62
1846.....	4,480,661	132,379	59
1847.....	.....	134,490	9
1848.....	.....	141,409	115
1849.....	4,613,080	131,493	383
1850.....	.....	176,211	478
1851.....	.....	133,245	508
1852.....	.....	134,921	343
1853.....	.....	124,617	42
1854.....	4,593,770	124,746	68
1855.....	.....	124,764	64
Total....	33,985,240	3,153,905	6,895
Average.	4,248,155	131,412 $\frac{17}{24}$	287 $\frac{1}{24}$

* The proportion of the total number of deaths to population,
1:32 $\frac{1}{3}$. The deaths from smallpox to population, 1:14,741 $\frac{2}{3}$.
Deaths from smallpox to total number of deaths, 1:457 $\frac{3}{4}$.

ARGUMENT OF OPONENTS OF VACCINATION

The opponents of vaccination—and they have been with us since the days of Jenner—admit the decline in smallpox referred to, but deny that the decrease was the result of vaccination. They declare it was due rather to the discontinuance of inoculation. This argument was carefully considered by the British Royal Commission on Vaccination. There can be no question that smallpox prevailed to a greater extent during the eighteenth century than during any period of which we have records. We must, furthermore, admit that the practice of inoculation tended to diffuse the infection of smallpox, inasmuch as inoculated smallpox was contagious and could be contracted much in the same manner as natural smallpox. The effect of inoculation was really twofold in character: It tended, on the one hand, to lessen the number of deaths from smallpox by producing a mild form of the disease, accompanied by mortality varying between 0.3 per cent. and 2 per cent., and by conferring protection against the dangerous natural smallpox. On the other hand, it tended to perpetuate smallpox in the community by reason of the fact that the inoculated persons, often scarcely ill, disseminated the disease among others. The lessening of the death-rate by protection from natural smallpox, on the one hand, and the tendency to diffuse the disease, on the other hand, constitute two opposing influences which largely neutralize each other as far as the aggregate number of deaths from smallpox is concerned.

Unfortunately for the contention of the opponents of vaccination, the increase in the prevalence of and mortality from smallpox during the eighteenth century was not coincident in point of time with the introduction and extent of employment of inoculation.

Inoculation was introduced into England in 1721, but comparatively few persons were inoculated before 1725. As is admitted by the two dissenting members of the Royal Commission on Vaccination, inoculation had no effect on the mortality from smallpox in the first quarter of the century (see page 354, Report of Dissentients, Sydenham Publication). Computation discloses the fact that from 1700 to 1725 the average yearly mortality from smallpox in London was 1,752. During the last quarter of the century, 1775 to 1800, when inoculation was much in vogue, the average yearly mortality was 1,817, an entirely insignificant increase. In-

deed, relative to the population the smallpox deaths were actually less during the latter period.

It has been, furthermore, alleged by the opponents of vaccination that the decline in the prevalence of smallpox at or about the beginning of the nineteenth century was the result of improvement in sanitary conditions. It may be conceded that such improvements as better drainage and sewerage, freer ventilation, purer water-supply, lessened crowding in dwellings, and the like, would, by improving the average individual health, tend to lessen the fatality of all infectious diseases, not excluding smallpox. But such influences are totally inadequate to explain the striking and progressive decline in the prevalence of and mortality from smallpox that followed the introduction of vaccination.

If sanitary improvements were responsible for the lessened mortality from smallpox, why did they not similarly influence the mortality from measles, scarlet fever, and whooping-cough, which are favored by the same conditions that aid the dissemination of smallpox? Smallpox and measles resemble each other in the sense that the spread of both diseases is not dependent on any special sanitary defect. Unlike typhoid fever and cholera, their occurrence is influenced by personal infection rather than by any definite vices of sanitation. Measles and smallpox are the most contagious of all diseases; a momentary exposure of an unprotected person to the infection of smallpox or measles suffices for such individual to contract the disease. According to the Registrar-General's Reports, during the same period in England that smallpox mortality has declined 72 per cent., the mortality from measles has fallen only 9 per cent. Furthermore, the death-rate from whooping-cough has declined but a little more than 1 per cent. (at present whooping-cough is the most fatal of all diseases in children under two years of age), and the diminution in the mortality of scarlet fever has become apparent only within comparatively recent years. Again the improvement in sanitation and mode of living has only caused a reduction of the general death-rate of the country (England) of 9 per cent.

The lack of parallelism between the incidence and mortality of smallpox and of other diseases due to bad sanitation is illustrated in the comparison of the Prussian and French troops in the Franco-Prussian war contained in Table 7.

TABLE 6.—DEATHS FROM SMALLPOX IN LONDON

Year.	Smallpox Deaths.	Year.	Smallpox Deaths.
1629.....	72	1698.....	1,813
1630.....	40	1699.....	890
1631.....	58	1700.....	1,031
1632.....	531		—
1633.....	72	1691-1700.....	11,028
1634.....	1,354		—
1635.....	293	1701.....	1,099
1636*.....	127	1702.....	311
1647.....	139	1703.....	398
1648.....	401	1704.....	1,501
1649.....	1,190	1705.....	1,095
1650.....	184	1706.....	721
1651.....	525	1707.....	1,078
1652.....	1,279	1708.....	1,687
1653.....	139	1709.....	1,024
1654.....	832	1710.....	3,138
1655.....	1,294		—
1656.....	823	1701-10.....	12,052
1657.....	835		—
1658.....	409	1711.....	915
1659.....	1,523	1712.....	1,943
1660.....	354	1713.....	1,614
	—	1714.....	2,810
1661.....	1,246	1715.....	1,057
1662.....	768	1716.....	2,427
1663.....	411	1717.....	2,211
1664.....	1,233	1718.....	1,884
1665.....	655	1719.....	3,229
1666.....	38	1720.....	1,442
1667.....	1,196		—
1668.....	1,987	1711-20.....	19,532
1669.....	951		—
1670.....	1,465	1721.....	2,375
1661-70.....	9,950	1722.....	2,167
	—	1723.....	3,271
1671.....	696	1724.....	1,227
1672.....	1,116	1725.....	3,188
1673.....	853	1726.....	1,569
1674.....	2,507	1727.....	2,379
1675.....	997	1728.....	2,105
1676.....	359	1729.....	2,849
1677.....	1,678	1730.....	1,914
1678.....	1,798		—
1679.....	1,967	1721-30.....	23,044
1680.....	689		—
1671-80.....	12,660	1731.....	2,640
	—	1732.....	1,197
1681.....	2,982	1733.....	1,370
1682.....	1,408	1734.....	2,688
1683.....	2,096	1735.....	1,594
1684.....	1,560	1736.....	3,014
1685†.....	2,496	1737.....	2,084
1686.....	1,062	1738.....	1,590
1687.....	1,551	1739.....	1,690
1688.....	1,318	1740.....	2,725
1689.....	1,389		—
1690.....	778	1731-40.....	20,592
1681-90.....	16,640		—
	—	1741.....	1,977
1691.....	1,241	1742.....	1,429
1692.....	1,592	1743.....	2,029
1693.....	1,164	1744.....	1,633
1694.....	1,683	1745.....	1,206
1695.....	784	1746.....	3,236
1696.....	196	1747.....	1,380
1697.....	634	1748.....	1,789
	—	1749.....	2,625
	—	1750†.....	1,229
	—		—
	—	1741-50.....	18,533

TABLE 6.—(Continued)

Year.	Smallpox Deaths.	Year.	Smallpox Deaths.
1751.....	998	1777.....	2,567
1752.....	3,538	1778.....	1,425
1753.....	774	1779.....	2,493
1754.....	2,359	1780.....	871
1755.....	1,988		
1756.....	1,608	1771-80.....	20,923
1757.....	3,296		
1758.....	1,273	1781.....	3,500
1759.....	2,596	1782.....	636
1760.....	2,181	1783.....	1,550
		1784.....	1,759
1751-60.....	20,611	1785.....	1,999
		1786.....	1,210
1761.....	1,525	1787.....	2,418
1762.....	2,743	1788.....	1,101
1763.....	3,582	1789.....	2,077
1764.....	2,382	1790.....	1,617
1765.....	2,498		
1766.....	2,334	1781-90.....	17,867
1767.....	2,188		
1768.....	3,028	1791.....	1,747
1769.....	1,968	1792.....	1,568
1770.....	1,986	1793.....	2,382
		1794.....	1,913
1761-70.....	24,234	1795.....	1,040
		1796.....	3,548
1771.....	1,660	1797.....	522
1772.....	3,992	1798.....	2,237
1773.....	1,039	1799.....	1,111
1774.....	2,479	1800§.....	2,409
1775.....	2,669		
1776.....	1,728	1791-1800.....	18,477

* The records of smallpox deaths from 1636 to 1647 have been lost, but it is known that in 1641 an extensive epidemic of the disease prevailed.

† Population within the Bills of Mortality estimated to be in 1685, 530,000.

‡ Population in 1750 estimated to be 653,900.

§ Population of London, determined by census, in 1801 was 746,233.

TABLE 7.—DEATHS PER 10,000 MEN *

Prussian Army		French Garrison of Langres	
Cause.		Cause.	
Smallpox	5.8	Smallpox	222.6
Dysentery	32.3	Dysentery	19.3
Typhoid	118.8	Typhoid	80.6

* Table taken from Lotz: Pocken und Vaccination, Basel, 1880; presented in evidence before the Royal Commission on Vaccination.

The Prussian army was greatly exposed to smallpox as a large part of it was invading France, where this disease was raging. It was known that vaccination was much more thoroughly carried out in the Prussian than in the French army.

Another noteworthy fact must not be forgotten, namely, that the decline in the death-rate from smallpox has been entirely limited to persons below the age of fifteen. It is evident, therefore, that the lives of an enormous number of children have been saved. It is

most illogical to attempt to explain such an inequality in the decline of smallpox mortality on the grounds of improved sanitation. The percentage of mortality borne by children who are the subjects of measles, scarlet fever, and whooping-cough does not differ materially from what it was a century ago.

The true explanation of the decline of smallpox mortality in children is that successfully vaccinated infants are almost completely protected against smallpox throughout the first decade of their lives. After this period, the vaccinal protection commonly begins to wane.

The decline in smallpox was manifest in all countries where vaccination was extensively practiced, no matter what the status of sanitation was. The case of Glasgow is a good example: The population of Glasgow in 1831 was almost five times what it was in 1780. There was overcrowding in tenement houses, lack of isolation in hospitals and absence of disinfection: the general sanitary condition was considered to be worse than that of any large town in England. Yet with an increasing population, with sanitation growing worse, with measles and whooping-cough deaths multiplying, the mortality from smallpox was lessened 80 per cent., with nothing to account for the reduction save vaccination.¹⁰

ISOLATION PROPOSED AS A SUBSTITUTE FOR VACCINATION

The isolation of smallpox patients and general sanitary measures are urged by the antivaccinationists as substitutes for vaccination. The isolation of patients suffering from transmissible diseases of any kind is recognized by all sanitarians as a most important procedure. But to disregard vaccination and rely on isolation to combat an extensive epidemic of smallpox would be an act of folly which would not be long tolerated by any intelligent community.

Anyone with practical knowledge of smallpox knows that smallpox is often not recognized until many persons have been exposed to infection. Mild cases of smallpox commonly escape detection while the patient is abroad in the community. Moreover, it is impossible to diagnose smallpox before the eruption appears; during the several days preceding the outbreak of the eruption those persons in contact with the patient may receive the infection of the disease.

10. Jenner Number of Public Health, 1896.

In regard to isolation, the Royal Commission on Vaccination says: "We can see nothing to warrant the conclusion that in this country vaccination might be safely abandoned and replaced by a system of isolation." The commission, of course, favored isolation as an auxiliary to vaccination.

Dr. Werner¹¹ refers to attempts to suppress smallpox by isolation in Germany before 1834.

Isolation was most rigidly enforced; the patients were removed to smallpox stations and special houses; even seals were placed on the door of the patients' rooms. The patients' clothes were disinfected or burnt, and themselves and their attendants kept under watch and ward. All to no purpose—the pest found a way through the closed doors till suppressed by vaccination without the cooperation of sanitary measures.

SMALLPOX IN THE VACCINATED AND UNVACCINATED

It is not claimed at the present day that a single vaccination will invariably protect against smallpox for life. In the endeavor of the opponents of vaccination to prove that vaccination does not protect against smallpox, statistics are frequently cited to show that a large number of vaccinated persons contract the disease. This is an argument on which the antivaccinationists are prone to lay great stress. The argument, however, is specious and merely demonstrates that a single vaccination does not, as a rule, confer life-long protection against smallpox. If provision is not made for the renewal of protection by revaccination at a later period, the subjects are only in a measure secured against smallpox. England and other countries have had for many years a compulsory vaccination law, but it has had reference only to vaccination in infancy. It has resulted in an enormous saving of child life, but it has failed to provide for the protection of adults after the vaccinal immunity has died out.

Germany is the only one of the great countries of the world that has had experience for a sufficient period of time with a compulsory vaccination and revaccination law properly enforced, and Germany has been for thirty-five years free of epidemics of smallpox, although the contiguous countries have suffered from epidemics of this disease.

11. Werner: Deutsch. med. Wehnschr., May 14, 1896.

THE CLAIMS FOR VACCINATION

It is easy to comprehend why a single vaccination may not be relied on for perpetual protection against smallpox. Smallpox itself is, in rare instances, followed by another attack later in life. Now if one attack of smallpox does not invariably protect against a second, how could we expect vaccination, which in reality represents a benign, non-contagious and attenuated smallpox, to accomplish this desired end?

1. *A successful vaccination protects the subject against smallpox for a period of time not mathematically determinable for the individual, but which averages seven to ten years.*

2. *The protection may be renewed by a second vaccination when the vaccinal immunity is exhausted. The revaccination restores the protection which lapse of time has diminished or abrogated.*

3. *Persons successfully vaccinated on two occasions are usually immune against smallpox for life.* There are exceptional instances, however, of unusually susceptible individuals in whom a third or fourth vaccination is required. These exceptions are comparable with those rare cases in which a person is susceptible to a second or third attack of smallpox.

4. *Persons vaccinated in infancy, who at some later period of life contract smallpox, have in the aggregate less severe and less frequently fatal attacks than unvaccinated persons.* The degree of favorable modification of the smallpox is in inverse proportion to the period of time elapsing between vaccination and the attack of smallpox. The statistics as to the mortality of smallpox in the vaccinated and the unvaccinated are later set forth.

5. *The beneficent effects of vaccination are most pronounced in those in whom the vaccine affection has run its most typical and perfect course, and who bear the best quality of vaccinal scars as attestation of the same.* The mere production of a "sore arm" does not necessarily imply that the individual has been successfully vaccinated.

STATISTICS OF SMALLPOX IN THE VACCINATED AND THE UNVACCINATED

The experience of one hundred years offers absolutely conclusive proof of a most pronounced difference in the mortality from smallpox in the vaccinated and the

unvaccinated. Variations in the severity of different epidemics occur, but the comparison of the death-rate in the two classes always yields the same result.

TABLE 8.—DEATH-RATE FROM SMALLPOX AMONG VACCINATED AND UNVACCINATED IN VARIOUS COUNTRIES *

Places and Time of Observation.	Total No. of Cases Observed.	Death Rate per 100 Cases.	
		Among the Unvac- cinated.	Among the Vac- cinated.
France, 1816-1841	16,397	16.125	1
Quebec, 1819-1820	?	27	1.66
Philadelphia, 1825	140	60	0
Canton Vaud, 1825-1829	5,838	24	2.16
Verona, 1828-1829	909	46.66	5.66
Milan, 1830-1851	10,240	38.33	7.66
Breslau, 1831-1833	220	53.8	2.11
Württemberg, 1831-1835	1,442	27.33	7.1
Carniola, 1834-1835	442	16.25	4.4
Vienna Hospital, 1834	360	51.25	12.5
Carintbia, 1834-1835	1,626	14.5	0.5
Adriatic, 1835	1,002	15.2	2.8
Lower Austria, 1835	2,287	25.8	11.5
Bohemia, 1835-1855	15,640	29.8	5.16
Galicia, 1836	1,059	23.5	5.14
Dalmatia, 1836	723	19.66	8.25
London Smallpox Hospital, 1836-1856	9,000	35	7
Vienna Hospital, 1837-1856	6,213	30	5
Kiel, 1852-1853	218	32	6
Württemberg (no date)	6,258	38.9	34
Malta (no date)	7,570	21.07	4.2
Epidemiological Society Returns (no date)	4,624	23	2.9

* Extract from papers prepared in 1857 by Sir John Simon, Medical Officer of the General Board of Health of England, and at that time laid before Parliament with reference to the History and Practice of Vaccination. Published in first Report of the Royal Commission on Vaccination, 1889, Appendix 1, p. 74.

The figures cited in Table 8 show that among thousands of cases of smallpox occurring in cities all over the world the death-rate from smallpox has been from five to sixteen times greater among the unvaccinated than among the vaccinated.

In an epidemic of smallpox in Marseilles, in 1828, the unvaccinated had a mortality of 25 per cent., as compared with 0.5 per cent. among the vaccinated.

The British Royal Commission on Vaccination presents the following statistics of six recent epidemics—in Dewsberry, 1891-92; Warrington, 1892-93; Leicester, 1892-93; London, 1892-93; Gloucester, 1892-93, and Sheffield. A grand total of 11,065 attacks is collected. This number resulted in 1,283 deaths, or 11.5 per cent., divided as shown in Table 9.

TABLE 9.—DEATHS AMONG VACCINATED AND UNVACCINATED IN SIX RECENT EPIDEMICS

	Vaccinated.	Unvaccinated.
Cases	8,744	2,321
Deaths.....	461	822
Per cent	5.2	35.4

The death-rate is therefore seven times greater among the unvaccinated than among the vaccinated.

THE RESULTS OF VACCINATION IN GERMANY

The relative immunity from smallpox mortality in the German army in 1871, as compared with that of the French army and of the civil population of Germany, led the German government to pass, in April, 1874, a general compulsory vaccination and revaccination law. The law requires the vaccination of all infants before the expiration of the first year of life, with revaccination at the age of 13.

Since the law of 1874 went into effect in Germany there have been no epidemics of smallpox in that country. The smallpox is frequently introduced by foreigners, particularly on the frontier, but the disease can find no foothold. In 1899 there occurred in the German empire, among 54,000,000 people, only 28 deaths from smallpox; these occurred in twenty-one different districts, the largest number in any one district being three. Not a death from smallpox occurred in a large town.

In 1897 there were but five deaths from smallpox in the entire German empire (54,000,000 population).

Furthermore, for a period of thirteen years, in a population comprising two-fifths of the total inhabitants of Germany, there were only five instances of death from smallpox in successfully revaccinated persons.

Germany has taught the world how to utilize Jenner's great discovery so as to exterminate epidemics of smallpox.

The German Vaccination Committee of 1884, referring to the influence of the compulsory vaccination law, said:

The remarkable and persistent decline in Prussia since 1875 can be due only to the vaccination law of 1874, because all other conditions remain the same in the two other countries (i. e., Austria and Germany). The only difference is that in Prussia the revaccination of all school-children at the age of 12 years was made compulsory in 1874.

TABLE 10.—DEATHS FROM SMALLPOX IN COUNTRIES WITH COMPULSORY VACCINATION AND THOSE WITHOUT COMPULSORY VACCINATION

Population.	Smallpox Deaths.				Average of Deaths.	Average Per Million of Population.	
	1886.	1887.	1888.	1889.			
Sweden*	4,746,465	1	5	9	2	4	1
Ireland*	4,808,728	2	14	3	0	5	1
Scotland*	4,013,029	24	17	0	6	12	3
Germany*	47,923,735	197	168	112	200	169	3.5
England*	28,247,151	275	505	1,026	23	458	16
Switzerland	2,922,430	182	14	17	3	54	18.5
Belgium	5,940,365	1,213	610	865	1,212	975	164
Russia	92,822,470	16,938	25,884	?	?	21,411	231
Austria	23,000,000	8,794	9,591	14,138	12,358	11,220	510
Italy	29,717,982	?	16,249	18,110	13,416	15,925	536
Spain	11,864,000	?	?	14,378	8,472	11,425	963

* Compulsory vaccination.

THE RESULTS OF VACCINATION REQUIREMENTS IN
VARIOUS COUNTRIES

The Board of Health of Berlin has prepared tables comparing the number of deaths from smallpox occurring between the years 1886 and 1889 in countries having compulsory vaccination and those without such provision.

But a glance is necessary to show the striking difference between the number of deaths in those countries having compulsory vaccination and those in which there is no such measure. The average deaths per million in the compulsory vaccination countries is eighty times less than in the others. Furthermore, England is the least vaccinated of the compulsory countries and her death-rate is the highest among these.

The Imperial Board of Health of the German Empire gives the frequency of smallpox in various European countries between 1893 and 1897, inclusive, a period of five years.

TABLE 11.—THE FREQUENCY OF SMALLPOX IN EUROPEAN STATES BETWEEN 1893-1897 INCLUSIVE (FIVE YEARS)

Country.	Population.	Average Yearly Mortality in Every Million Population.	Actual Number Smallpox Deaths.	Year.
Germany	52,042,282	1.1	287	5
Denmark	793,356	0.5	2	5
Sweden	4,894,790	2.1	41	4
Norway	2,045,900	0.6	5	4
England and Wales.....	30,389,524	20.2	3,066	5
Scotland	4,155,886	12.3	256	5
Ireland	4,580,555	9.9	226	5
Switzerland	3,032,901	5.1	78	5
Netherlands	4,797,249	38.7	929	5
Belgium	6,419,498	99.9	3,208	5
French States	8,253,079	90.2	3,721	5
Russian Empire, including Asiatic Russia	118,950,400	463.2	275,502	5
Austria	23,000,000	99.1	11,799	5
Italy	31,007,422	72.7	11,278	5
Spain	10,596,649	563.4	23,881	4
Hungary	18,234,916	134.3	12,241	5

Here, again, the countries which during this period have the most stringent vaccination laws suffer the least smallpox, namely, Germany, Denmark, Sweden and Norway.

In well-vaccinated Germany, but one person a year in every million of population died of smallpox.

In England and Wales, where vaccination is generally but not universally practiced, 20 persons per million died of smallpox each year.

It is, indeed, quite possible to know to what extent vaccination is practiced in the various countries by noting the mortality from smallpox.

The tables teach another lesson, namely, that without vaccination smallpox is still to be regarded as a dread scourge—as a great destroyer of human life. For in the five years from 1893 to 1897, in the sixteen countries mentioned, 346,520 lives were sacrificed to smallpox; of this number Russia lost 275,502. These figures are the more terrible when it is recognized that these lives might have been saved by the application of a prophylactic measure within the reach of all.

Thorough vaccination has practically banished smallpox from the huge German army. Kübler¹² says:

On only two occasions since the year 1874 (in 1884-85 and in 1889) has a death from smallpox occurred in the Prussian Army, and the first of these was in the person of a reservist who seven years before had been twice unsuccessfully vaccinated.

VACCINATION IN THE PHILIPPINE ISLANDS

Of particular interest is the recent achievement of the United States sanitary authorities in stamping out smallpox in the Philippine Islands. In 1905 and 1906 the enormous number of 3,094,635 vaccinations were performed. Dr. Victor G. Heiser, Director of Health of the Islands, in the Report of the Bureau of Health (June 30, 1907), states:

In the provinces of Cavite, Batangas, Cebu, Bataan, La Union, Rizal and La Laguna, where heretofore there have been more than 6,000 deaths annually from smallpox, it is satisfactory to report, since the completion of vaccination in the afore-said provinces more than a year ago, not a single death from smallpox has been reported.

SMALLPOX EVER PRESENT IN PERSIA BECAUSE OF NEGLECT OF VACCINATION

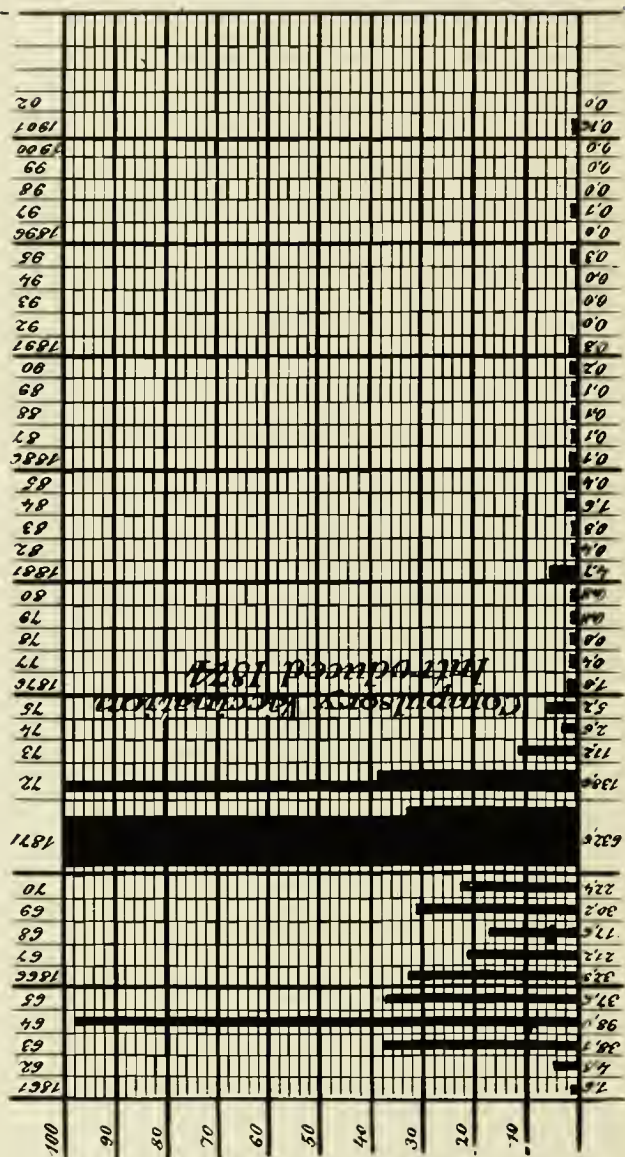
A letter received by the Marquis of Salisbury from Dr. T. F. Odling, Medical Officer to the Indian Government Telegraphs, dated from Teheran, May 14, 1891, reads in part as follows:¹³

Vaccination is not compulsory in Persia and, except amongst the better class of people in large towns, it is not generally carried out; inoculation is still to a large extent the custom in the districts. . . . Smallpox is endemic and the large ma-

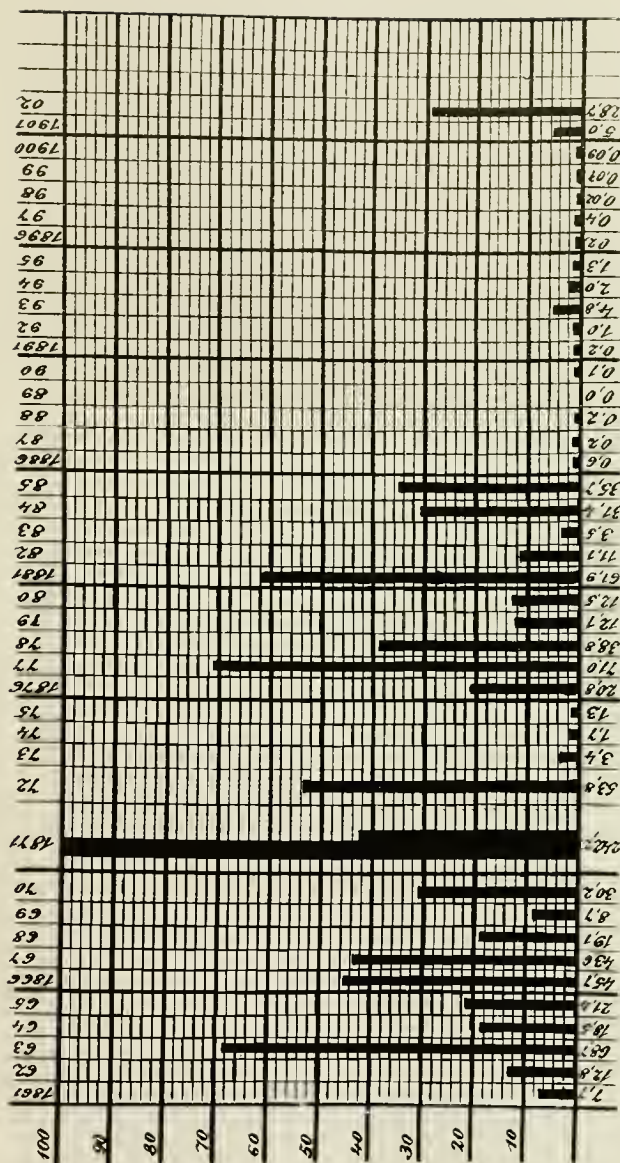
12. Kübler: *Geschichte der Pocken und der Impfung*, 1901, p. 383.

13. Extract from evidence presented before the Royal Commission on Vaccination, Appendix No. 15, p. 756.

BERLIN.—Smallpox Mortality Per 100,000 of Population.

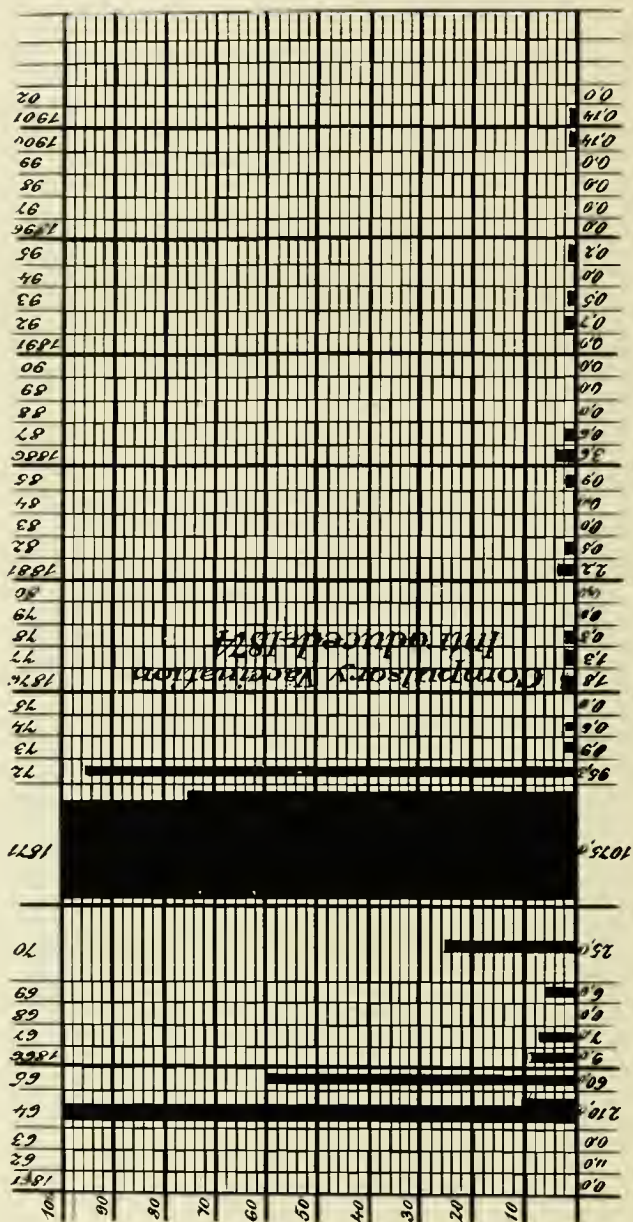


LONDON.—Smallpox Mortality Per 100,000 of Population.

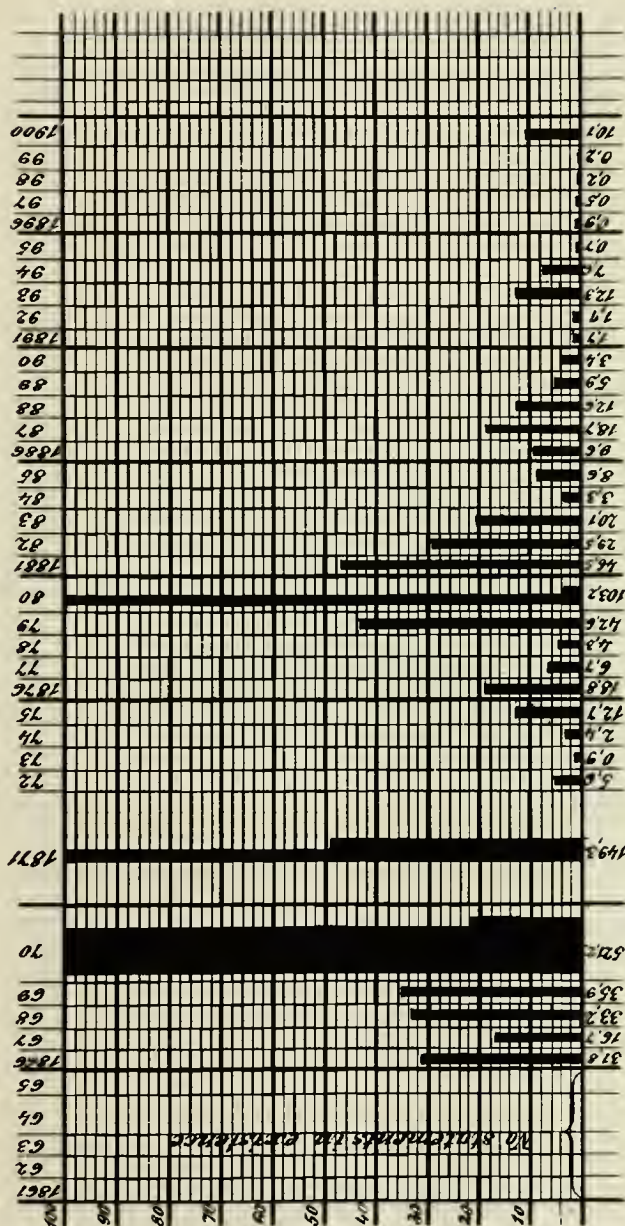


CHARTS 1 AND 2 (BERLIN AND LONDON).—Comparison of mortality from smallpox per 100,000 of population. Since 1874, Germany has a well-enforced compulsory vaccination and revaccination law, while England has merely compulsory vaccination in infancy not generally enforced. (This chart and the others in this article are part of a series published by the German Government in 1904.)

HAMBURG.—Smallpox Mortality Per 100,000 of Population.

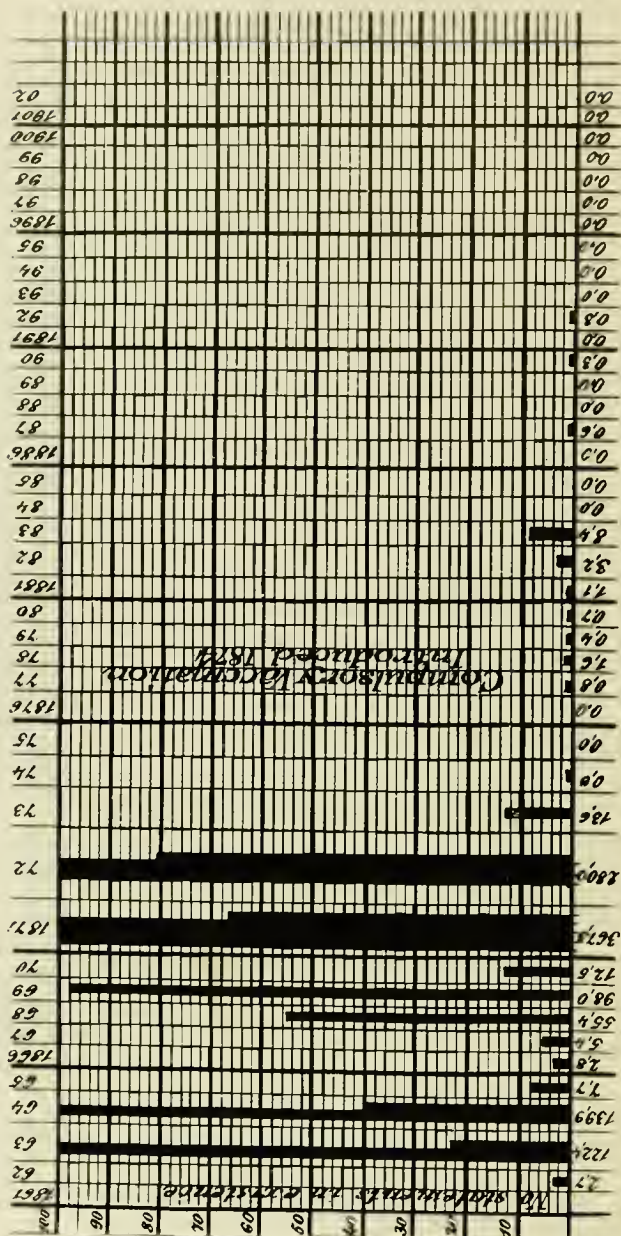


PARIS.—Smallpox Mortality Per 100,000 of Population.

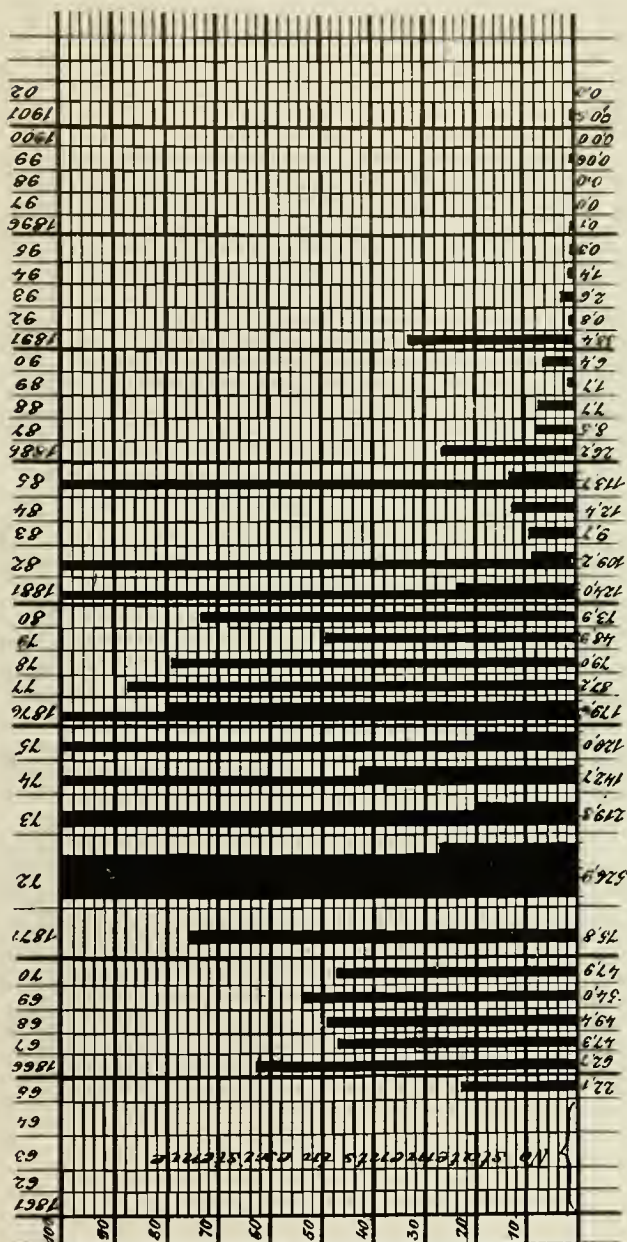


(CHARTS 3 AND 4 (HAMBURG AND PARIS).—Comparison of mortality from smallpox per 100,000 of population. In Hamburg, no compulsory vaccination before 1874; since then compulsory vaccination and revaccination. In Paris no compulsory vaccination.

BRESLAU.—Smallpox Mortality Per 100,000 of Population.

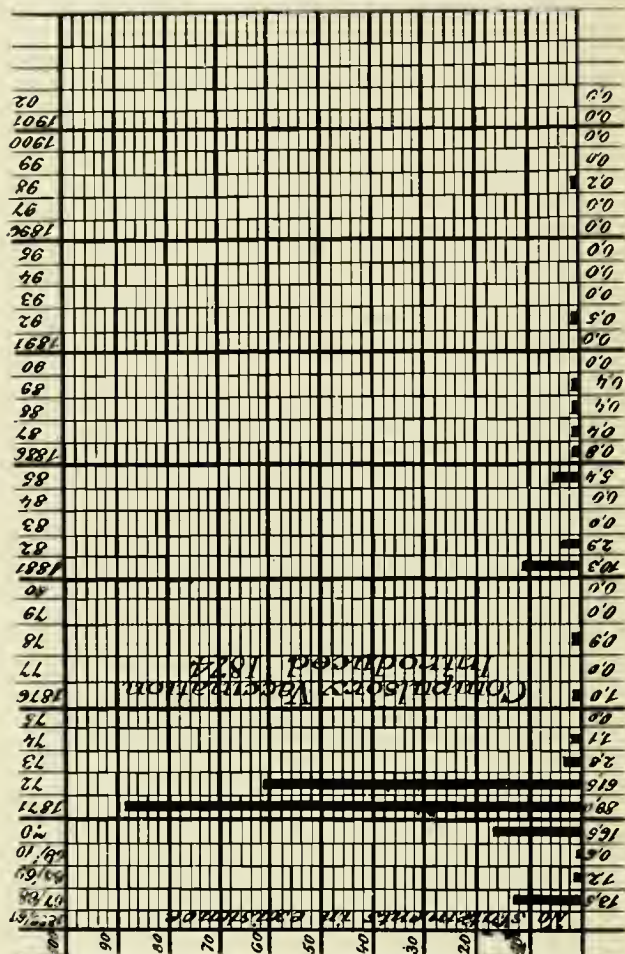


VIENNA.—Smallpox Mortality Per 100,000 of Population.

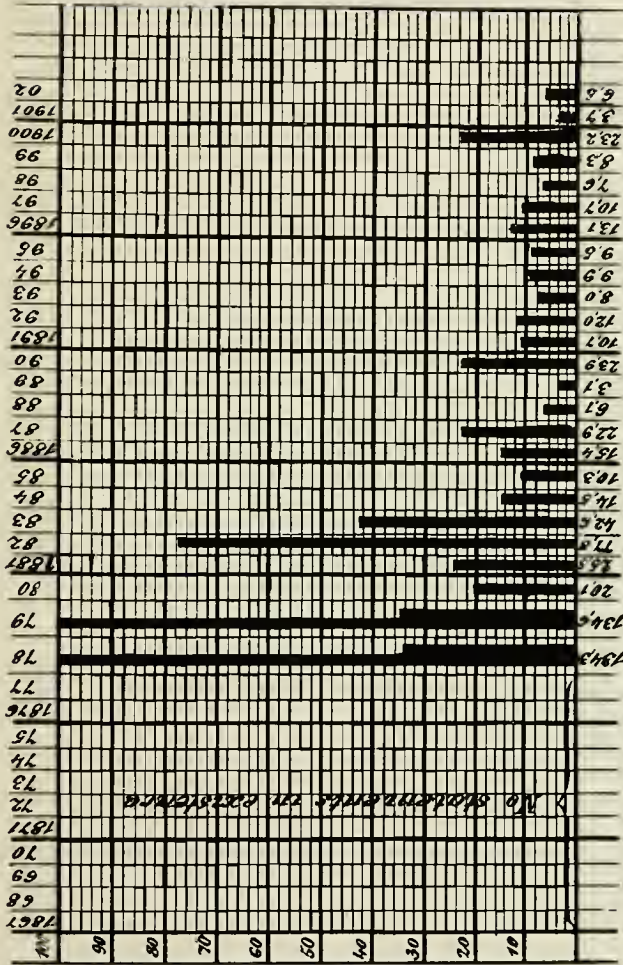


CHARTS 5 AND 6 (BRESLAU AND VIENNA).—Comparison of mortality from smallpox per 100,000 of population. In Breslau no compulsory vaccination before 1874; since then compulsory vaccination and revaccination. In Vienna no compulsory vaccination, but since 1891 the administrative government authorities have used their best efforts in furthering vaccination.

MUNICH.—Smallpox Mortality Per 100,000 of Population.

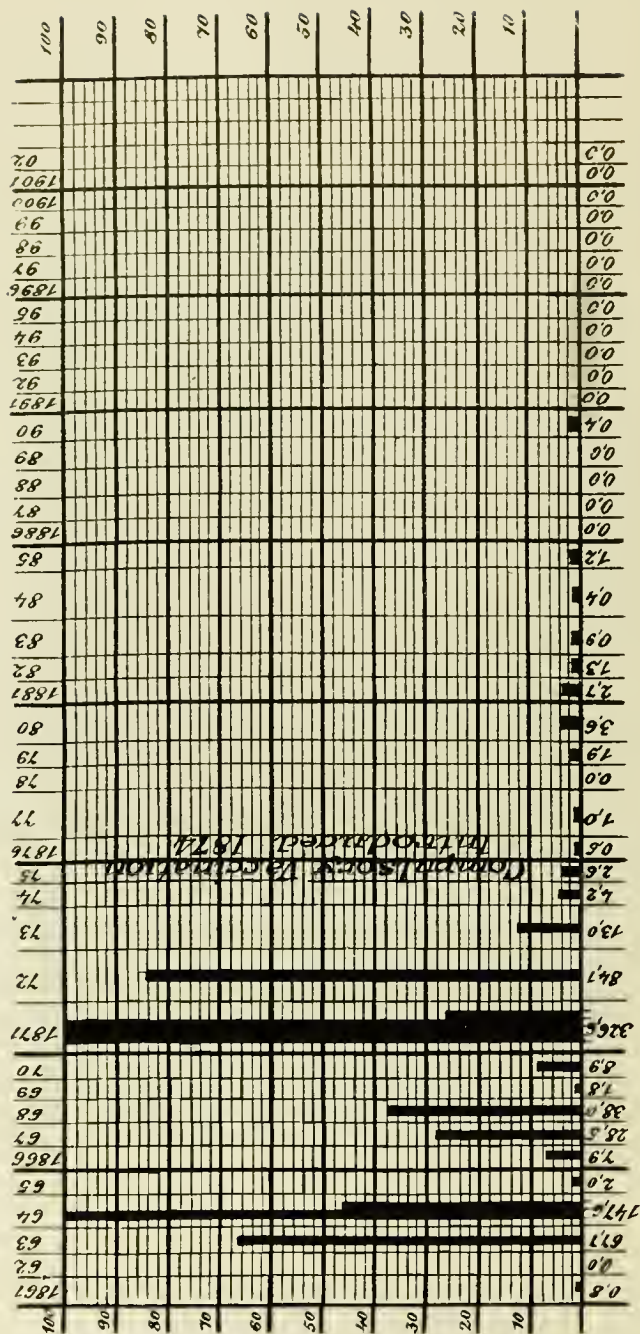


ST. PETERSBURG.—Smallpox Mortality Per 100,000 of Population.

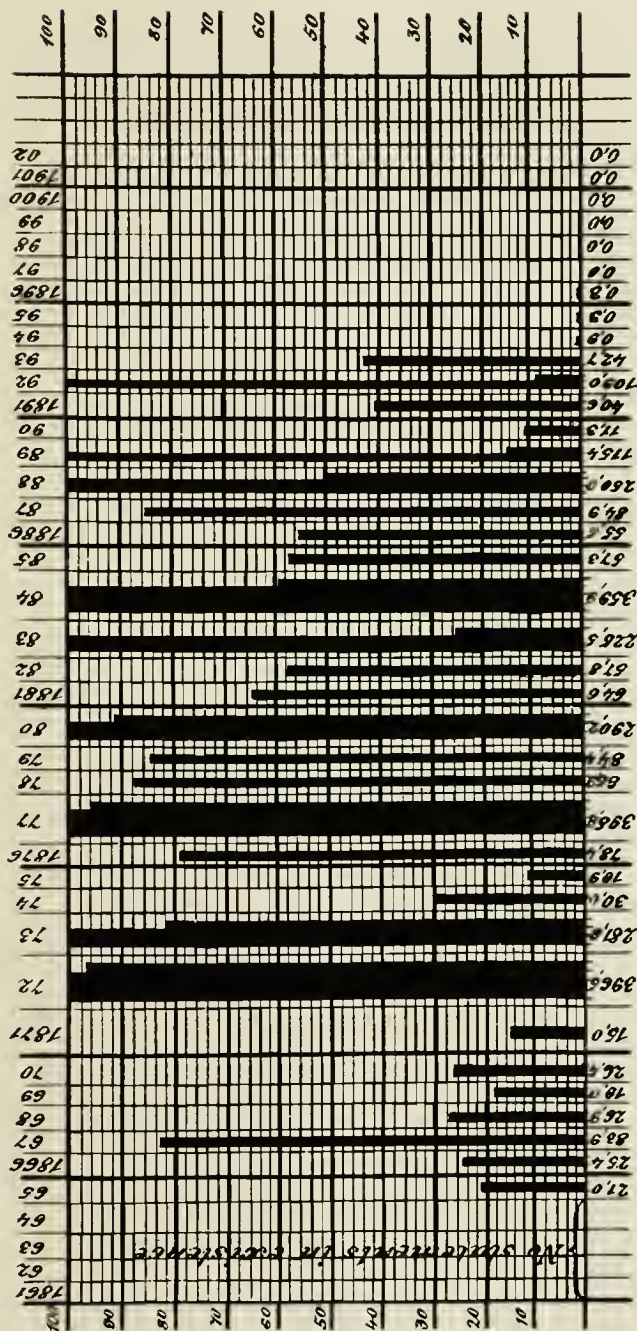


CHARTS 7 AND 8 (MUNICH AND ST. PETERSBURG).—Comparison of mortality from smallpox per 100,000 of population. In Munich before 1874, vaccination once for all; since then compulsory vaccination and revaccination. In St. Petersburg no compulsory vaccination.

DRESDEN.—Smallpox Mortality Per 100,000 of Population.



PRAGUE.—Smallpox Mortality Per 100,000 of Population.



CHARTS 9 AND 10. (DRESDEN AND PRAGUE).—Comparison of mortality from smallpox per 100,000 of population. In Dresden no compulsory vaccination before 1874; since then compulsory vaccination and revaccination. In Prague no compulsory vaccination

jority of children suffer from this disease at an early age. The deaths caused by smallpox are considerable, and the permanent injury in addition to the disfigurement caused by pitting inflicted on those who recover is very great, the loss of one eye or serious defect of vision being the most common.

TERRIBLE SLAUGHTER OF GUATEMALAN INDIANS BY SMALLPOX IN 1890

The decimating effects of smallpox in communities where vaccination is neglected may be further exemplified by reference to an epidemic in Guatemala in 1890-91. In an official dispatch, dated March 14, 1891, of Mr. Audley Gosling to the Marquis of Salisbury, the following is stated:¹⁴

I regret that the epidemic of smallpox which has raged here during the past fifteen months is still swelling the death-rate of this republic.

It is computed that since the first of January, 1890, no less than 112,000 deaths have occurred from this terrible scourge. The epidemic has been chiefly confined to the Indian population.

Mr. Gosling encloses a letter from Dr. Q. H. Arton, practicing in Guatemala, who writes:

The natives have a strong prejudice to vaccination, simply because it involves the use of a lancet or other instrument, and not from any dread of the process *per se*. . . . So pig-headed are they, however, that although they have proofs given them of the power to stop the epidemic in villages in which it is rampant, yet they will sooner attribute any cessation of the disease to the procession of some saint, and this belief is kept up by their so-called spiritual guides, who are in many cases equally ignorant with their flocks.

IMMUNITY OF VACCINATED PHYSICIANS, NURSES AND ATTENDANTS IN SMALLPOX HOSPITALS

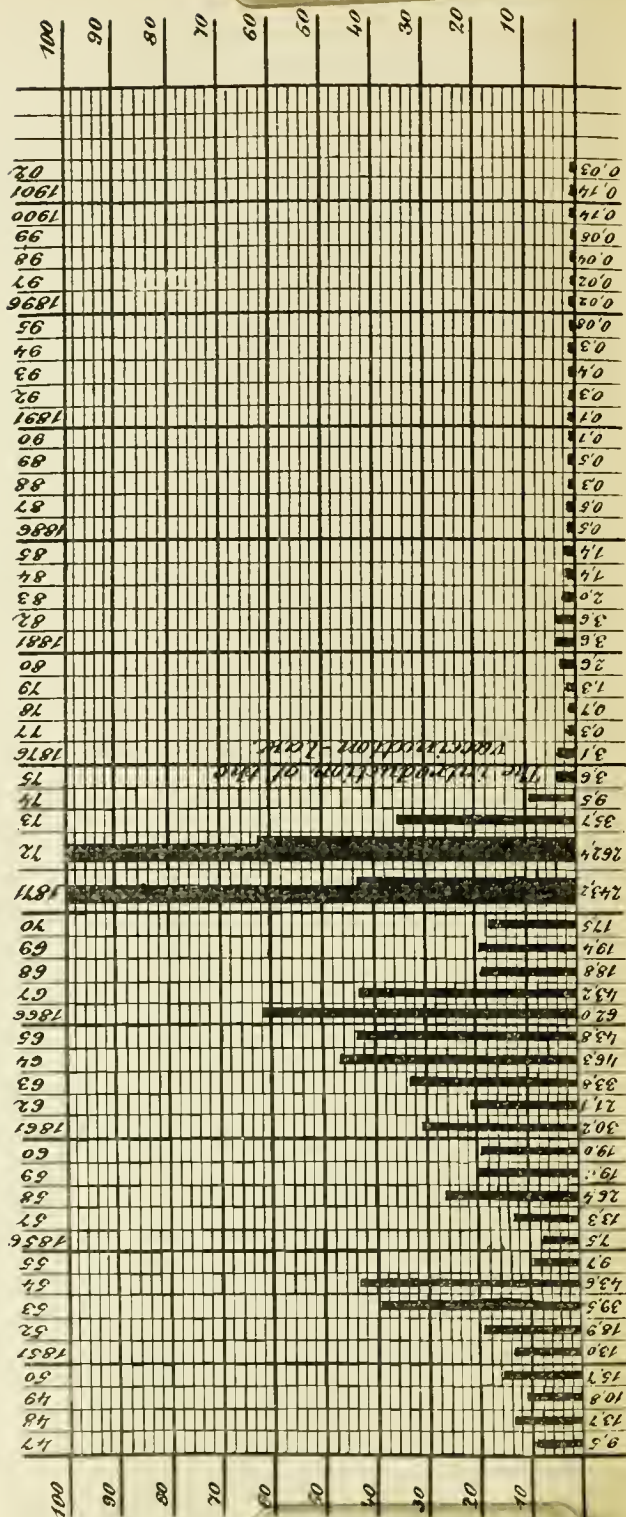
If it can be demonstrated that physicians, nurses and attendants in smallpox hospitals can be perfectly protected by vaccination, then this must be regarded as a crucial test of its protective influence: for if these persons, living in the same atmosphere with scores or hundreds of smallpox patients, breathing their very exhalations, are enabled to escape the infection, it certainly should be possible for others much less exposed to acquire similar immunity.

Experience shows that physicians, nurses and attendants, if recently successfully vaccinated or revaccinated,

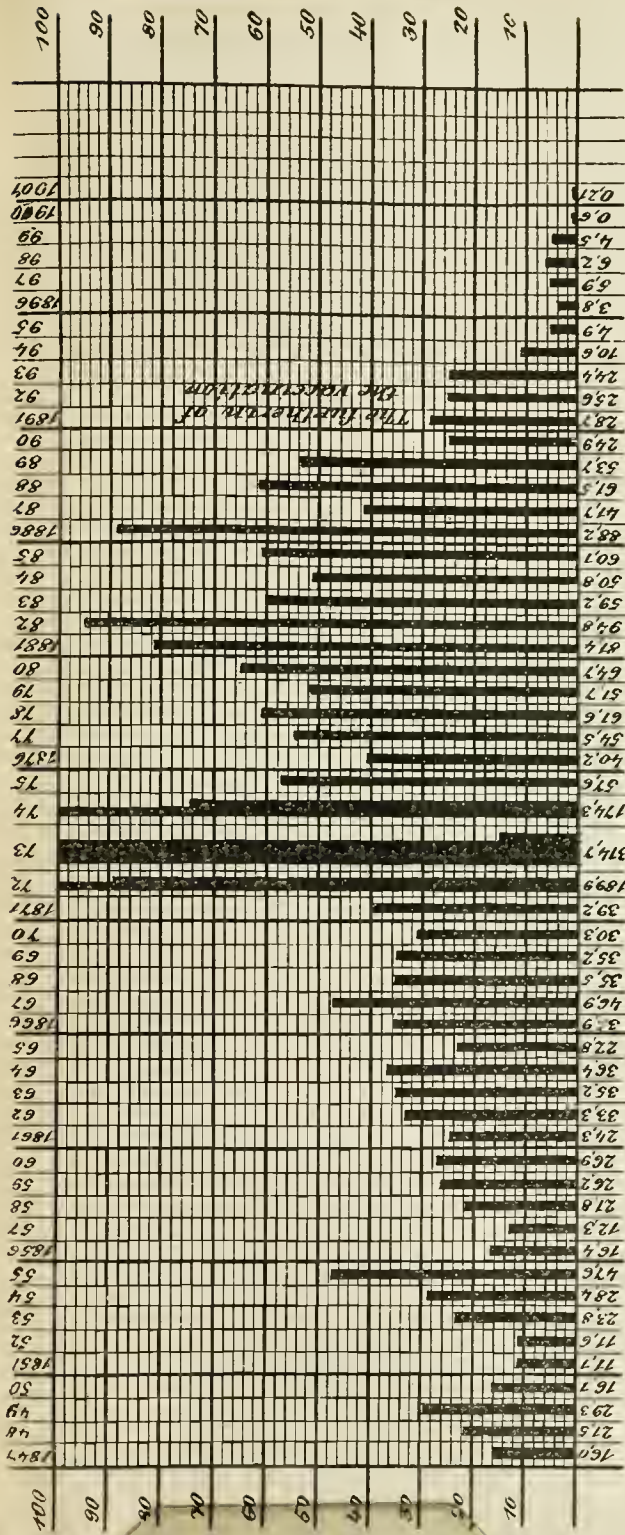
14. Extract from evidence presented before the Royal Commission on Vaccination, Appendix No. 15, p. 765.



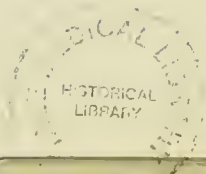
PRUSSIA. Smallpox Mortality Per 100,000 of Population.



AUSTRIA.—Smallpox Mortality Per 100,000 of Population.



CHARTS 11 AND 12 (PRUSSIA AND AUSTRIA).—Comparison of mortality from smallpox during the years 1816-1902. There was very little difference in the number of deaths from the disease in the two countries as long as compulsory vaccination had not been introduced; since the enactment of the German vaccination law in Prussia, however, the mortality there has sunk to a previously unknown figure, whereas it has remained stationary and at the same high rate in Austria for many years. Up to 1889 the mortality from smallpox in the latter country was on an average greater than it was before the epidemic in 1872, and it is only since 1890 that favorable conditions have again prevailed, although the losses from smallpox have remained greater during recent years than in Prussia.



may live in smallpox hospitals in perfect safety. Dr. Marson, physician to the Smallpox Hospital of London for many years, giving evidence in 1871, stated that during the preceding thirty-five years no nurse or servant at the hospital had been attacked with smallpox. Dr. Marson took the precaution of revaccinating all attendants before permitting them to go on duty. Dr. Collie, whose experience is also large, says: "During the epidemic of 1871, out of one hundred smallpox attendants at Homerton (England) all but two were revaccinated, and these two took smallpox." Dr. T. F. Ricketts, medical superintendent of the smallpox hospital ships on the Thames, states that out of 1,201 persons in attendance on board the smallpox ships, only six contracted the disease, all of them recovering. None of these six persons had been successfully revaccinated before going on duty. According to Dr. Hill, of Birmingham (England), during the epidemic of 1893, over one hundred persons were employed at the City Smallpox Hospital, all of whom had been recently revaccinated; not one of them contracted smallpox.

Dr. William M. Welch, of Philadelphia, states that in the Municipal Hospital of Philadelphia during a period of thirty-four years, in which time almost 10,000 cases of smallpox were treated, there was no instance of a physician, nurse or attendant who had been successfully vaccinated or revaccinated prior to going on duty contracting the disease.

EXPERIENCE OF THE MUNICIPAL HOSPITAL OF PHILADELPHIA IN THE EPIDEMIC OF 1901-1904

During this period over 3,500 cases of smallpox were received at the hospital. Not one patient, recently successfully vaccinated, was admitted to the hospital with smallpox. During the period of the outbreak of smallpox in Philadelphia, it is estimated that about 500,000 persons were vaccinated—approximately a third of the population. If vaccination confers no protection against smallpox, it is reasonable to suppose that some of these persons would have contracted the disease and been brought to the hospital. (About 80 per cent. of all the cases in the city were sent to the hospital.) But no such patient could be found among over 3,500 admissions.

In order to provide accommodations in the Municipal Hospital for the unusually large number of cases of



Fig. 1.—Two children in the Municipal Hospital of Philadelphia in 1903, one unvaccinated and the other vaccinated on the day of admission; the crust is still seen on the leg. This child remained in the hospital with its mother, who was suffering from smallpox for three weeks and was discharged perfectly well. The unvaccinated child, admitted with smallpox, died. (From "Acute Contagious Diseases," Welch and Schamberg.)



Fig. 2.—Three members of a family brought to the Municipal Hospital of Philadelphia with the mother, who was suffering from smallpox. The child in the center was unvaccinated; the other two had been vaccinated one year before as they were being prepared for kindergarten. These two children remained in the smallpox wards several weeks and left the hospital perfectly well. (From "Acute Contagious Diseases," Welch and Schamberg.)

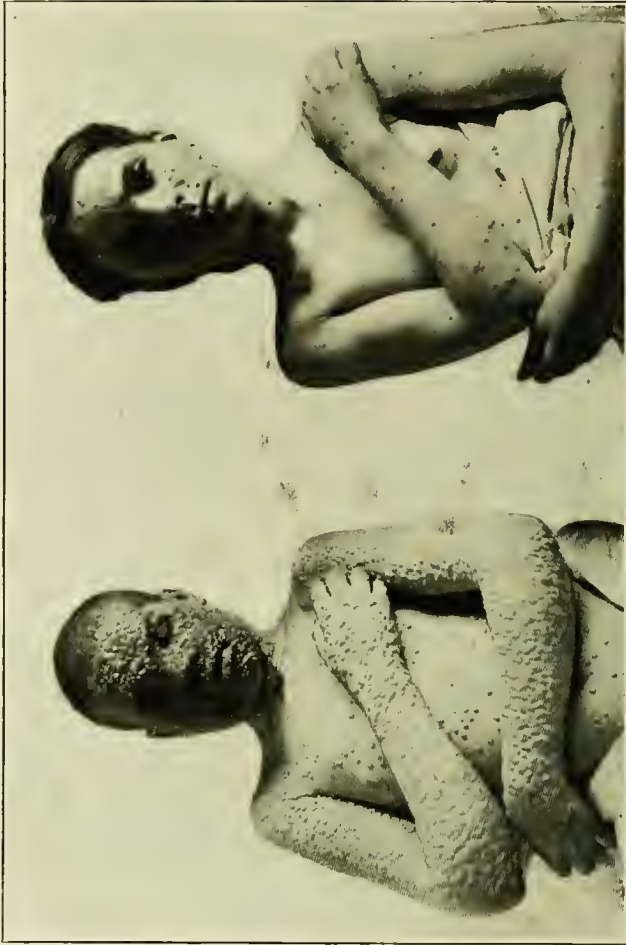


Fig. 3.—Two sisters, suffering from smallpox. The one on the right, aged 14, was successfully vaccinated in infancy, but not since. She contracted a mild smallpox, was never very ill and recovered without any scarring. The vaccinal scar is seen on the left arm. The girl on the left, aged 13, was never vaccinated. She developed a severe smallpox, which threatened her life and vision, but finally recovered although badly disfigured. Treated in the Municipal Hospital of Philadelphia in 1902. (From "Acute Contagious Diseases," Welch and Schamberg.)

smallpox, which was rapidly increasing, it was necessary to erect additional buildings as well as enlarge those already in use. On this work from fifty to sixty men were employed, and, as they were required to come constantly into close proximity to the patients, they were all requested to come to the administration building and be vaccinated. This request was complied with by all except two, and these two took the smallpox. They were the only ones that were stricken by the disease. Later it was found necessary to enlarge some of the



Fig. 4.—A normal appearance on the seventh day of vaccination. Compare the picture with that of smallpox.

buildings still further, and other workmen were employed. Two of them, for some reason which was never learned, neglected to get vaccinated before commencing the work, and they both took the smallpox.

The medical schools of Philadelphia had the privilege of sending their more advanced students to the Municipal Hospital for clinical instruction in the various contagious and infectious diseases therein treated. From

1901 to 1904 between 900 and 1,000 students visited the smallpox pavilions and spent one or two hours among scores of virulent smallpox cases. One of the requirements was that each student had to show evidence of protection, either by having been recently successfully vaccinated or by not responding to vaccination after two or three careful trials. Of the entire number but one contracted smallpox, and it was subsequently found that not only had he never been successfully vaccinated, but that he came from an antivaccination family and was opposed to this prophylactic measure.



Fig. 5.—Destruction of the eyeball from smallpox; it was necessary later to remove the eye.

During the epidemic of 1901-1904 about 200 persons, including physicians, nurses, ward-maids, cooks, laundresses, and the like, were employed in the smallpox department, and not one contracted the disease; all, of course, had been vaccinated or revaccinated before going on duty.

Dr. William M. Welch, of Philadelphia, says: "In every epidemic of smallpox that has occurred in Philadelphia within the past thirty years, instances have been observed of whole families being removed to the

hospital because of an outbreak of the disease in these families. In such instances the unvaccinated children have suffered and often perished, while those who were vaccinated remained perfectly exempt, although living, eating and sleeping in the infected atmosphere for several weeks. But I have yet to see unvaccinated children escape the disease under similar conditions of exposure. Furthermore, I have more than once seen a vaccinated infant take the daily supply of nourishment from the breast of its mother who was suffering from smallpox, and the infant continue as free from smallpox as if the disease were one hundred miles away and the food derived from the most wholesome source. This is evidence of the prophylactic power of vaccination that does not appear in mortality reports nor in statistical records."¹⁵

PHYSICIANS AND NURSES NOT PROTECTED AGAINST OTHER CONTAGIOUS DISEASES

Physicians and nurses do not exhibit immunity toward other contagious diseases as they do with respect to smallpox. According to Ernest Hart, in 1893, of 2,484 persons employed in the Metropolitan Fever Hospital of London, 130 became infected and 2 died. Four assistant medical officers, 10 nurses, 43 assistant nurses, and 16 maid servants were attacked by scarlet fever. Two assistant medical officers, 6 nurses, and 15 assistant nurses contracted diphtheria.

While the deaths from smallpox of physicians (who constitute a class particularly well vaccinated) are but 13 per million, in England, the deaths of the general population are 73 per million. In scarlet fever, on the other hand, against which physicians have no special protection, the figures are reversed: 59 medical men per million die of scarlet fever, as against 16 per million of the general population.

ALLEGED DANGERS OF VACCINATION

Every human act is accompanied by some measure of danger. When one rides in an elevator, in a railroad car, or even promenades on the sidewalk, he takes a certain definite risk which can be mathematically calculated. While in the aggregate the number of accidents and deaths from each of these causes may be considerable, yet the individual risk is so small that it may be disregarded. It is the same with reference to vaccination.

15. Welch and Schamberg: *Acute Contagious Diseases*, Philadelphia, 1905.

Inasmuch as vaccination necessitates the production of an abrasion or wound, it is naturally liable to infections to which wounds from other causes are subject. Such a trivial accident as a pin-scratch or razor-cut has been known to lead to fatal termination. Most of the infections after vaccination occur in persons in whom regard for cleanliness is slight and for the subsequent care of the vaccination site is neglected.

If there is any class of men in the community who should be familiar with the accidents and complications of vaccination, it should certainly be the physicians. With this knowledge in their possession, medical men regard vaccination as so safe a procedure that they almost universally employ this measure on themselves, their wives, and their children. Indeed, physicians and their families constitute the best vaccinated class in the community. As has been said, English statistics show that only 13 medical men per million die of smallpox, against 73 per million of the general population, and the contrast is all the more striking in view of the fact that physicians are more exposed to smallpox than the average citizen.

Practically all of the accidents of vaccination are preventable by the selection of the proper virus and care of the arm during and after vaccination. The United States Public Health and Marine-Hospital Service has supervision over the products of all vaccine establishments doing an interstate business and has the power to revoke the license of a firm placing impure virus on the market.

The dangers of vaccination have been enormously exaggerated by the opponents of this measure. In the Philippine Islands within the past few years there have been performed by the United States sanitary authorities 3,515,000 vaccinations without a single death or any serious postvaccinal infection.¹⁶ When we consider the thousands on thousands of vaccinations performed, even on the unclean and under unfavorable circumstances, and note how rare it is for any serious complication to develop, we are justified in concluding that the risk attending vaccination in any individual case is practically a negligible quantity. The danger connected with vaccination is infinitesimal compared with the peril of remaining unvaccinated.

16. Strong, R. P.: Combating Tropical Diseases in the Philippines by Scientific Methods, *THE JOURNAL A. M. A.*, Feb. 15, 1909, lii, 524.

UNANIMITY OF AUTHORITATIVE OPINION ON
VACCINATION

It is difficult to understand that a medical procedure, which has stood the test of over one hundred years of experience and has satisfied the judgment of physicians and scientists, should encounter organized opposition outside of the profession. There has probably never been in the history of mankind a great discovery, the acceptance of which some men did not dispute. The great truth which Jenner gave to the world offers no exception to this statement. There are dissenters who do not believe in vaccination, but they are few in number and chiefly to be found outside of scientific circles. I know of no physician of eminence in this country who is not a believer in—nay, even an ardent advocate of vaccination. Every civilized government in the world has placed the stamp of its official sanction on vaccination, and practically all nations have made this procedure compulsory in their armies and navies. There is almost complete unanimity of sentiment among physicians concerning the efficacy of vaccination as a safeguard against smallpox.

The effort on the part of the lay opponents of vaccination to diffuse the idea that there is a pronounced difference of opinion among physicians as to the virtues of vaccination is absolutely without foundation in fact. It would be a difficult matter to find in this country five physicians in a hundred who are opposed to vaccination. Belief in the efficacy of vaccination has been repeatedly affirmed by the most noted scientific bodies in the world. Even as early as 1802 a committee of the British House of Commons investigated the subject and made a favorable report on the protective power of vaccination. In 1807 the Royal College of Physicians of London made a favorable report to the House of Commons. In 1804 a royal commission appointed in Denmark arrived unanimously at the conviction that vaccine virus was a preservative from smallpox. In 1856 John Simon, the medical officer of the London Board of Health, sent circular letters to 542 prominent members of the medical profession in the United Kingdom and Europe, requesting opinions as to the value of vaccination; 539 replies were received and there was absolute unanimity expressed as to the efficacy of vaccination as a protective measure against smallpox.

The most important opinion has been rendered by the British Royal Commission on Vaccination appointed by Queen Victoria in 1889. This commission, consisting of eminent members of Parliament, lawyers, scientists and physicians, and presided over by Lord Herschell, carried out an exhaustive investigation, lasting from 1889 to 1897. It held 136 meetings and examined 187 witnesses. The judgment of such a body as to the efficacy of vaccination should certainly be regarded as conclusive. In the final report signed by eleven of the thirteen members is found the following statement:

It is to be hoped that our report will stimulate belief in the efficacy of vaccination, that it will remove some misapprehension and reassure some who take an exaggerated view of the risks connected with the operation, as well as lead to a more ready enforcement of the law by local authorities.

To our knowledge, no scientific society has ever passed resolutions derogatory to vaccination; on the other hand, the highest scientific bodies throughout the world have repeatedly affirmed their belief in the virtues of vaccination.

On May 13, 1893, the Royal College of Surgeons of England, one of the most eminent bodies in Great Britain, transmitted to the Royal Commission on Vaccination a set of resolutions bearing on vaccination, which reads in part as follows:¹⁷

We consider the evidence in favor of its life-saving power to be overwhelming, and we believe, from evidence equally strong, that the dangers incidental to the operation, when properly performed, are infinitesimal.

We should, therefore, regard as a national calamity any alteration in the law which now makes vaccination compulsory.

ANIMAL RESEARCH IN ITS RELATION TO VACCINATION AND SMALLPOX

The tradition concerning the protective influence of cowpox against smallpox appears to have been known to dairymen in England and Germany long before the days of Edward Jenner. Dairy servants whose hands were accidentally infected with cowpox while milking cows were alleged to be immune against the ever-present and fatal smallpox.

After assiduous investigation extending over many years, Jenner became convinced that there was truth in

17. Rep. Roy. Com. on Vaccination, Appendix No. 22, p. 778.

this strange belief. He carefully studied cowpox in the bovine and in the human species, and finally, after devoting much time and thought to the subject, inoculated material from the hand of a dairymaid on the arm of a young boy with complete success.

It remained for Jenner to crystallize the half-forgotten cowpox tradition into a scientific hypothesis, and then by painstaking study and experiment to prove its truth to the world.

The propositions set forth by Jenner may be briefly summarized as follows:

There is a disease affecting the heel of the horse which has been called by farriers "the grease."¹⁸ Dairy servants who come into contact both with horses and cows, accidentally transfer this affection from the horse to the cow in the process of milking the latter. An affection termed cowpox is thus produced on the udders and teats of the milch cows. Persons milking such cows commonly contract sores of a similar character on their hands. These persons are afterward immune against smallpox.

While Jenner's experimentation consisted largely in inoculating or rather vaccinating from one human subject to another, the material employed was primarily derived from the cow, which was, in its turn, accidentally inoculated from another cow or from the horse, usually through the mediation of the milker. An undesigned series of animal experiments was thus unconsciously carried out.

Jenner concerned himself also with some experimental research on cows in order to determine the stage at which the fluid from the equine affection was most likely to produce cowpox. In a footnote in his first publication in 1798 he says:

This [pus] I have often inserted into scratches made with a lancet on the sound nipples of cows, and have seen no other effects than simple inflammation.

The results of these experiments may have influenced the precept which, in his "golden rule of vaccination," Jenner later expressed, "never to take the virus from a vaccine pustule for the purpose of inoculation after the efflorescence is formed around it."

18. It is the prevailing belief nowadays that "the grease" or horsepox was not a necessary antecedent to cowpox; the two affections, in all probability, had a common ancestry.

EXPERIMENTS BEARING ON THE RELATION OF VACCINATION TO SMALLPOX

With the best qualified and most persistent opponents of vaccination, such as Prof. E. M. Crookshank and Dr. Charles Creighton, the alleged lack of relationship between cowpox or vaccinia and smallpox constituted a vital argument in support of their views. It was maintained that, vaccinia and variola being two unrelated affections, the inoculation of the virus of the one could not possibly protect against the other. Had the basic premise been proved to be true, the conclusion would have had much scientific, though theoretical, weight. The force of this argument, however, has been annihilated within recent decades by the proof that a most intimate relationship exists between vaccinia and smallpox. Indeed, it has been demonstrated that the intensely contagious virus of smallpox can be transformed into the benign vaccine virus, the latter having the property of protecting against smallpox when inoculated into the human subject. Moreover, the affection produced by the vaccine virus, unlike that produced in the last century by inoculation of smallpox virus, results in a disorder which is non-contagious. This proof of the relation between vaccinia and smallpox has been brought about through animal experimentation carried on through many years by scientific men in France, Switzerland, Germany and Great Britain. The British Royal Commission on Vaccination has thoroughly investigated these experiments and has reviewed the same in its voluminous report. While the experiments on the variolation of the bovine species have yielded results which exhibit marked variation, a considerable number of positive results have been attained in the hands of careful and trustworthy investigators at different times and in different countries. Fischer and Voigt in Germany, Haccius in Switzerland, Copeman in England, King in India, and others of late years have propagated cowpox virus by variolating heifers, producing thus what has been called variola-vaccine lymph. It has thus been conclusively demonstrated that smallpox may be converted into cowpox by successive inoculations of calves through several generations, the final inoculation yielding a pure vaccine virus. This virus when transferred to the human subject confers protection against smallpox.

It has taken almost a century of experimentation to prove the truth of the statement made by Jenner in his first publication, that smallpox and cowpox were modifications of the same disease. What a tribute to the intuitive discernment of this great man!

THE VALUE OF THE ABOVE EXPERIMENTS

The demonstration of the proof that vaccine virus may be developed from smallpox virus is of the greatest importance to mankind. Cases of spontaneous cowpox, from which most strains of vaccine lymph were originally derived, are excessively rare. In Württemberg, in 1825, a reward was offered for the discovery of cases of spontaneous cowpox. There is a reassuring sense of security, therefore, in the knowledge that in a case of the loss or attenuation of existing strains of lymph a fresh source may be obtained by variolation of calves. It has long been known that vaccine lymph may degenerate by too prolonged transmission through the human species. In years gone by the cry was often heard, "Back to the cow."

Again, in the event of a vaccine famine such as occurred in 1871-72, or in the case of an extensive epidemic of smallpox in some remote and inaccessible country where vaccine material could not be secured, the ability to convert the smallpox virus into vaccine virus by inoculation of calves would offer the means of suppressing the epidemic. Shakespcare might well have had vaccination in mind when he wrote:

Take thou some new infection to thine eye,
And the rank poison of the old will die.

ADVANTAGES OF BOVINE VIRUS OVER HUMANIZED VIRUS

1. About a quarter of a century ago it was the common practice to employ for vaccination the fluid or the dried crust from the vaccine lesion on a child's arm. While such vaccinations gave satisfactory results as regards protection against smallpox, they were attended with certain disadvantages which are obviated by the use of bovine lymph. The use of calf-propagated virus precludes the possibility of transmitting by vaccination diseases peculiar to the human species. One of the most weighty reasons that led to the adoption of animal vaccination and to its preference over arm-to-arm transmission was the recognition of the possibility of inducing syphilis by vaccine inoculation. To be sure, such acci-

dents were so rare that thousands on thousands of physicians vaccinating throughout a lifetime failed to encounter any such unfortunate experience. Nevertheless, no matter how uncommon such a catastrophe might be, the remotest liability of such an occurrence constitutes a serious argument against the use of humanized virus. The opponents of vaccination bitterly attacked the procedure on the grounds just mentioned. The bovine species being totally insusceptible to syphilis, the use of lymph of calf origin is entirely devoid of the danger of transmitting syphilis. The weightiest argument of those who have antagonized vaccination is, therefore, nullified.

Erysipelas appears to be a much rarer complication since the general employment of animal virus. Many cases of vaccinal erysipelas were, in the past, doubtless due to secondary infection of the vesicle at the time that it was punctured to withdraw lymph for further vaccinations. The use of animal virus obviates the necessity of tapping the vaccine vesicle, thus rendering erysipelas from this cause practically non-existent. Many cases of erysipelas were also due to the use of crusts which had been unwisely selected or improperly preserved. Whatever the cause or causes may have been, actual experience shows an enormous reduction in the relative and total incidence of this complication since calf virus has come into general use.

2. The virus of calves offers an almost inexhaustible supply of lymph, inasmuch as a much greater yield can be obtained from the calf than from the human subject, and, furthermore, the number of calves used can be multiplied according to existing needs. During extensive epidemics of smallpox when humanized virus was employed, the community was often placed in a most embarrassing and dangerous predicament owing to an insufficient supply of vaccine lymph. During the great pandemic of smallpox that spread over the entire globe in the early seventies a veritable vaccine famine existed in many countries. All kinds of sources were drawn on for virus, and much worthless lymph derived from spurious and irregular vaccinations was employed, with entirely unsatisfactory results.

3. Animal lymph appears to give a much larger percentage of successful revaccinations than long-humanized virus. Dr. Henry A. Martin says:

The number of those who in revaccination with old, long-humanized virus (not that of early human removes) experience vaccinal effect may be stated at the outside at 35 per cent. The number of those revaccinated with equal care and repetition with animal virus and virus of very early human removes, I affirm to be a fraction over 80 per cent.—a difference of 45 per cent.; and this 45 per cent. I firmly believe to represent approximately the number of those insensible to the enfeebled influence of long-humanized virus, but sensible to the intense contagion of variola just in the same degree as sensible to the intense power of bovine virus and that of the early human removes from it.

4. Vaccination with bovine lymph produces a vesicle which approaches more nearly the Jennerian prototype, and reaches, therefore, a greater degree of perfection than that produced by long-humanized virus.

The cowpox accidentally produced on the hands of dairymaids was believed by Jenner to confer lasting protection against smallpox. The bovine species appears to be the natural soil of the prophylactic pock, and the view has been maintained by many that calf virus or virus derived from an early human remove creates a more complete and permanent immunity.

It has been alleged by the opponents of vaccination that tuberculosis has been and is transmitted by the use of calf virus. The precautions which are adopted in the propagation of vaccine virus make such an accident almost an impossibility. Even were this not the case, it is very doubtful whether an inoculation of virus contaminated with the tubercle bacillus would produce more than a local skin lesion which could be readily cured. The precautionary measures employed are, as has been said, an all-sufficient safeguard. The virus is obtained from very young calves, and it is pretty well established that calves are but rarely the subjects of tuberculosis. It is stated by Fürst,¹⁹ on the authority of Pfeiffer, that but one case of tuberculosis was found among 34,400 calves under four months of age. The statistics of the abattoirs of Augsburg and Munich corroborate the above figures; only one tuberculous calf was discovered at Augsburg among 22,230 slaughtered, and the percentage was much smaller at Munich.

Furthermore, in all well-regulated establishments for the propagation of vaccine virus, the calves are sub-

19. Fürst: *Die Pathologie der Schutz-Pocken-Impfung*, Berlin, 1896, paragraph 431, p. 112; quoted by Acland: *Allbutt's System of Medicine*.

jected for a number of days prior to vaccination to the tuberculin test: in the event that tuberculosis is shown to exist in the animal, it is, of course, not employed for vaccination. All calves used for vaccination are autopsied and carefully examined before the virus obtained from them is placed on the market. Finally, even though it were possible, despite these precautions for the tubercle bacillus to contaminate the lymph, it would perish if the virus were glycerinated. Nearly all of the vaccine lymph now employed is subjected to the process of glycerination. Copeman,²⁰ speaking of glycerinated lymph, says:

The tubercle bacillus is effectively destroyed even when large quantities of virulent cultures have been purposely added to the lymph.

EXPERIMENTAL RESEARCHES ON MONKEYS

A number of observers, including Zuelzer, Copeman, De Haan, Roger and Weil, Park, Ewing, and Councilman, McGrath and Brinckerhoff, have shown that it is possible to inoculate certain species of monkeys with smallpox, producing in them a mild affection similar to inoculated smallpox formerly induced for protective purposes in man. This inoculation protects the monkey against subsequent successful inoculation and likewise against vaccination. Monkeys are only slightly, if at all, susceptible to smallpox contracted in a natural way through the air. Professor Councilman, of Harvard University, and his associates allege that they have discovered the parasite which causes smallpox, the same organism somewhat modified being held to be present in the vaccine lesion. If this claim is confirmed and proved by further research, results of practical importance may be evolved from the labors of these investigators.

RECAPITULATION AND CONCLUSIONS

VACCINATION AND SMALLPOX

1. Vaccination, when properly and adequately employed, protects one against smallpox. Even those intimately exposed to the disease, as physicians and nurses in smallpox hospitals, may be rendered completely immune against smallpox by vaccination and revaccination.

²⁰ Copeman: *Vaccination, Its Natural History and Pathology*, London, 1899, p. 181.

2. Vaccination protects against smallpox in the same manner that one attack of the smallpox protects against a second attack. Vaccination has the special advantage in that the immunity which it confers against smallpox may be renewed when it becomes impaired or exhausted.

3. Vaccination in order to confer protection must be genuine: the mere production of a "sore arm" is of itself no proof that the subject has been successfully vaccinated. The vaccination must run a definite course before a protective substance is left in the body.

4. Smallpox may develop in vaccinated persons if they have permitted years to elapse without being re-vaccinated.

5. Vaccination and revaccination universally applied are capable of exterminating smallpox as an epidemic disease. The experience of Germany during the past thirty-five years proves this.

6. In isolated instances individuals in a generally well-vaccinated community may develop smallpox because their protection is imperfect as a result of the use of an inert virus or because of some other fault of technic. These cases, however, will never appreciably influence the prevalence of the disease in such a community.

7. Smallpox was an ever-present and terrible pestilence in the days before vaccination. In most civilized centers it is to-day a relatively rare disease. This change has been effected almost exclusively by vaccination. Epidemics of smallpox prevail from time to time when the spark of infection is introduced into the community and a sufficient amount of unvaccinated combustible material exists to lead to a general conflagration. In countries where vaccination is neglected, as in Persia, Asiatic Russia, etc., etc., smallpox is still a death-dealing scourge.

8. The foes of vaccination commonly refer to the infrequency of smallpox at the present day and to the remote liability of contracting the disease. They forget that the relative security which we now enjoy is the result of vaccination. This security can be made absolute or it can be largely destroyed according as vaccination and revaccination are generally employed or generally neglected.

9. The dangers connected with vaccination have been greatly exaggerated by the opponents of this measure.

Vaccination causes an abrasion of the skin and in rare instances this wound, like other wounds may become infected, especially when neglected or maltreated. With the selection of a proper virus and care of the vaccination site during and after vaccination, the risk in any individual instance is an entirely negligible quantity. The risk connected with vaccination is infinitesimal compared with the peril of remaining unvaccinated.

THE RELATION OF ANIMAL RESEARCH TO OUR KNOWLEDGE OF SMALLPOX AND VACCINATION

1. Numerous experiments on calves have proved that smallpox virus may be converted into vaccine virus by transmission through several generations of the bovine species. This discovery not only establishes vaccination as a thoroughly scientific practice, but also provides for a new source of lymph in the event of the deterioration or loss of existing strains.

2. Experiments on calves have resulted in a method of calf vaccination which permits of the production of any needed quantity of virus. This renders unnecessary the use of humanized virus with the attendant disadvantages elsewhere referred to. The use of calves for the propagation of vaccine lymph constitutes the most important improvement in vaccination since its discovery over a hundred years ago.

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